Solar Thermal Propulsion Flight Experiment

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One of the space transfer technologies of promise in the Advanced Space Transporta-tion Program is solar thermal propulsion. This type of propulsion system could be used for advanced upper stages that could provide low-cost transportation of payloads from low-Earth orbit to geosynchronous-Earth orbit and beyond. Solar thermal propulsion requires large lightweight concentrators, high-tempera-ture materials for the engine, integrated controls and pointing, and long-term storage of cryogenic hydrogen. Several of these technologies are being matured to support solar thermal propulsion including a flight experiment to demonstrate a solar thermal propulsion system in space operation. This experiment is called the shooting star experiment (SSE) and will be flown in FY99. Deployed configuration is shown in figure 13.

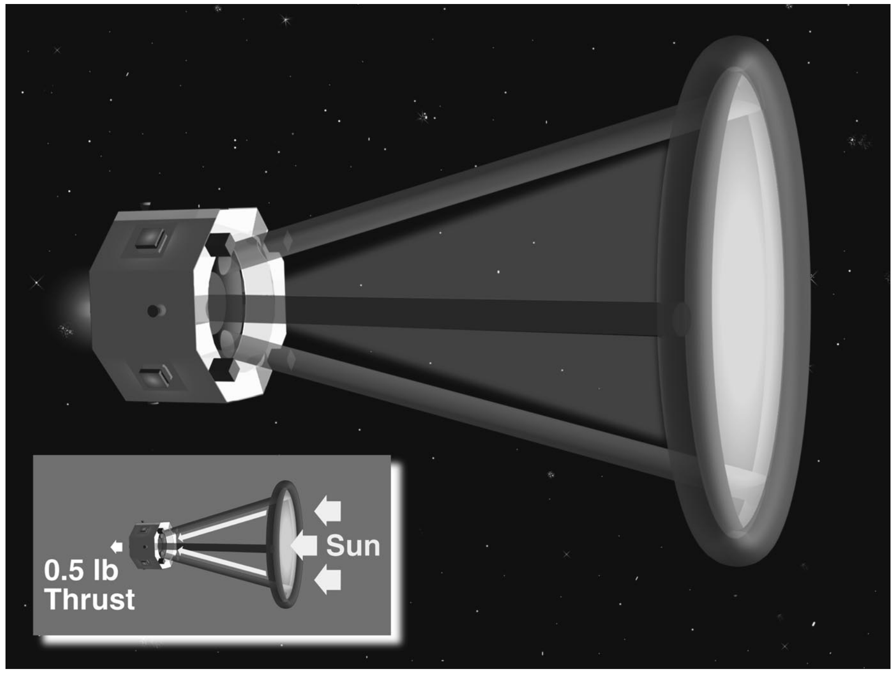

FIGURE 13.—Deployed flight configuration of shooting star experiment.

The shooting star experiment will demonstrate the deployment of a light-weight inflatable support structure, precise sun acquisition and collection, high-temperature engine operation resulting in high specific impulse (Isp). The experi-ment is designed to concentrate solar energy with a fresnel lens that will be connected to an inflatable torus which will be supported by three inflatable struts. The concentrated solar energy will be focused into a thermal storage engine where stored propellant will be used to provide a small thrust. The inflatable concentrator system will be launched deflated and packaged in a container to protect it during pre-launch processing and launch environments and to reduce the launch vehicle payload volume.

The spacecraft bus is the physical structure to which all the subsystem components will be attached and will interface to the launch vehicle via the payload adapter interface. It also provides the thermal protection to all subsystems from the thermal engine module. The thermal engine assembly is designed to convert the solar energy focused into the engine inner cavity, store it as heat and transfer the energy to a gaseous propellant injected into the engine heat exchanger, resulting in an increased Isp over that obtained by just flowing the monopropellant through the engine nozzle. For SSE, the engine is operated in pulse mode, (i.e., it is thermally charged and then discharged by injecting the propellant when the operating temperature is reached). During the experiment operation, multiple cycles will be attempted, at increasing start-point temperatures. The final goal is 2,760 °C. At this temperature, it is estimated the resulting Isp should approach 800 sec.

There will be a Sun-centering detector system to direct the focused solar flux into the engine cavity. The cavity diameter is about 3.8 cm. Part of the Fresnel lens will be dedicated to provide a light ring at the approximate outer diameter of the bus where four optical detectors will be located. The centering processor will forward commands to the guidance and control software for corrections to keep the energy centered. A lost Sun mode has been baselined in order to reorient the SSE lens from any orientation back toward the Sun.

The electronic heart of the SSE is the on-board computer system (OBCS), (fig. 14), and the inertial measuring unit (IMU). The OBCS contains and executes the pro-grammed sequential and housekeeping software and the IMU provides naviga-tional and stability measurements. All experiment functions are controlled in flight by the OBCS. There is no capability for ground control after launch.

The successful space demonstration of several key technologies in this flight experiment will help mature solar thermal propulsion to the point where full-scale development of an upper stage using this technology could be undertaken.

Sponsor: Advanced Space Transportation Program

University/Industry Involvement: University of Alabama in Huntsville; United Applied Technologies; Plasma Processing, Inc.

Biographical Sketch: Leslie A. Curtis serves as manager for the Space Transfer Technologies project in the Advanced Space Transportation Program office. She has responsibility for in-space transportation technology including upper stages, transfer stages, and on-board propulsion systems. Curtis has worked for NASA at MSFC for 13 years.

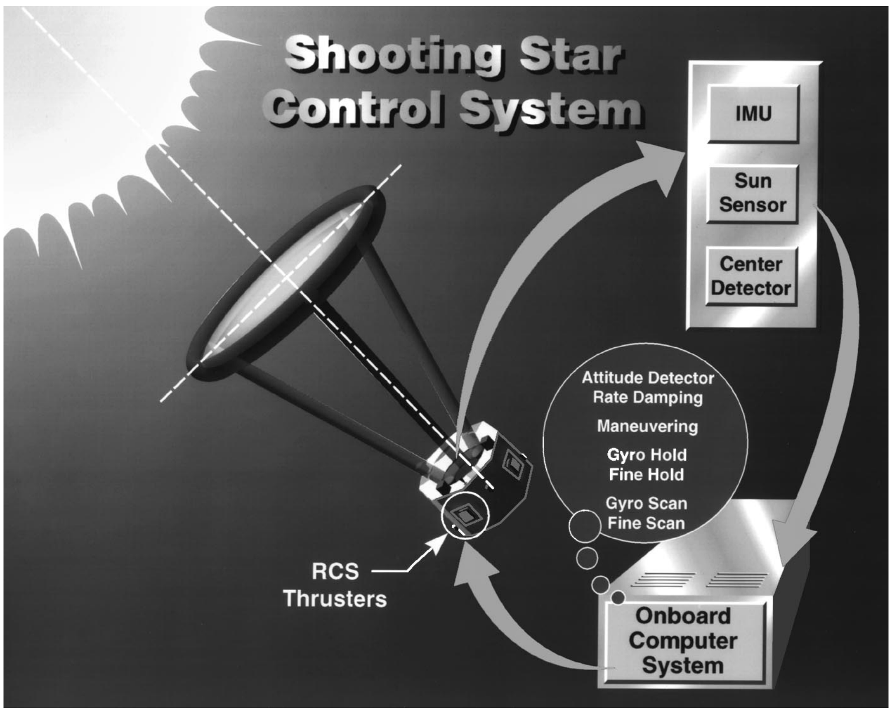

FIGURE 14.—Shooting star control system.